

## THE THAMES ESTUARY.

ALTHOUGH it is not practicable to say precisely where the river ends and the estuary commences, it will be sufficient for general purposes if the westward, or inner, boundary of the Thames estuary is assumed to be a line from Southend to Sheerness, the northern boundary as the coast of Essex, and the southern the coast of Kent; and it may be said to extend eastward to the meridian of the Kentish Knock light-vessel. The area inclosed between these lines is upwards of 800 square nautical miles, and the whole of the space is encumbered with banks, between which are the several channels leading to the river.

As the shores of Essex and Kent are low, and have no natural features by which they may be distinguished at a distance, and as a great part of the estuary is out of sight of land, even in the clear weather so rare in this country, it is evident that artificial marks in considerable number are required to make navigation at all practicable between the banks. In early times, when vessels were small and of light draught, few marks were necessary, but with increasing trade, necessitating vessels of heavy draught, new channels have to be marked farther from shore, and the demand for additional security to navigation has especially increased of late years, so that now there are no less than 3 lighthouses, 11 light-vessels, 8 gas buoys, 10 beacons, and 117 ordinary buoys marking the channels at present in use; and the demand for additional marks is likely to increase rather than diminish, for the deepest channels through the estuary have not yet been buoyed, and the changes in progress seem to favour the opinion that before many years some of them will have to be opened up to facilitate traffic.

In endeavouring to give an account of the changes in the channels of the estuary, it is difficult to obtain any authentic records earlier than the commencement of the present century. If such records exist, they are not at the Admiralty or Trinity House, the earliest surveys worthy of notice being those of Mackenzie, Graeme Spence, and Thomas, between 1790 and 1810; but no thorough investigation appears to have been taken up until Sir Francis Beaufort was Hydrographer, when, under his instructions, Captain Bullock surveyed the whole estuary between 1835 and 1845. Since then, Calver re-surveyed the whole of the southern part in 1862-63, and examined the northern banks in 1864, and lately the *Triton* has re-surveyed all the important channels and delineated the banks, and from these several surveys some idea can be obtained of the condition of the estuary at different epochs, and of the changes that are taking place.

These changes seem to be of two kinds; viz. permanent changes and periodic changes.

Before, however, describing the changes in progress, it will be well to give a general description of the estuary; and, to render the description more intelligible, three plans have been constructed, the first showing the whole estuary on a small scale with the tracks followed by vessels; the second being a diagram showing the state of an obstruction in a channel at different epochs, a characteristic permanent change; whilst the third plan shows the state of the Duke of Edinburgh Channel from the time of its first opening out to the present date, to illustrate what seems to be a channel opening and closing periodically.

It is worthy of notice that all the banks of the estuary are of sand intermixed with shells; even the foreshore consists mostly of sand, between high and low water marks; in two places only is it of shingle (viz. off Whitstable and at Garrison Point, Sheerness); and in a few places, near the entrance of the rivers discharging into the estuary, there is a little mud, whilst in the vicinity of Margate there are some ledges of chalk. The sand is very fine, and although, when dry, it possesses a tolerably hard surface, directly it begins to be covered it is all alive.

When beacons are erected on any of the banks, or a ship gets on shore, the tidal streams scour out the sand in the immediate neighbourhood, and cause the wrecks to sink and finally disappear. Although without actual boring it is not possible to give the exact depth of these sands, it is probable that they are upwards of 60 feet thick, for channels of that depth have opened out across the sands and again closed up, so that the bank has been dry at low water where 60 feet formerly existed; and the Goodwin Sands, in the Downs, which have been bored, proved to be 80 feet in thickness. All the banks, and the channels between them, trend in a north-east and south-west direction: this is doubtless due to the fact that the stream outside the estuary is running to the northward whilst the tide is ebbing from the river, and, consequently, the ebb stream in the estuary is deflected to the north-eastward.

The channels into the estuary, therefore, must be classed under two headings: (a) those which follow the main line of the flood and ebb streams, and (b) those which do not follow the general stream of the tide.

In the former category are the Warp, West Swin, Middle Deep, East Swin, Barrow Deep, Oaze Deep, and Black Deep; in the latter are the Middle Swin, Queen's Channel, Prince's Channel, Alexandra Channel, Duke of Edinburgh Channel, Gore Channel, &c., which are all more or less of the nature of swatchways across the main line of the sand-banks of the estuary. In the Black and Barrow Deeps, which are the deepest and straightest channels through the estuary, the ebb stream runs 7 hours and the flood 5 hours, and the ebb is much stronger than the flood, the stream setting fairly through. In the Duke of Edinburgh Channel, the deepest swatchway of the estuary, the streams at the north and south ends are of a rotatory character, revolving with the hands of the clock.

I would here explain that in a large space like the Thames estuary the difficulty of buoying the various channels increases very considerably with their distance from the shore. With permanent marks erected on the shore, it is easy to place buoys in selected positions, not far from land, in fairly clear weather. But when the distance from the shore has increased so that the marks erected on the land cannot be seen, we have either to erect other marks on the sand-banks and carry out a triangulation, or we are dependent on floating bodies (fixed by land objects) to fix other floating bodies farther off. That this is an eminently unsatisfactory method will be evident when it is stated that each time the Kentish Knock light-vessel has been satisfactorily fixed, the position has been very different from that supposed. When fixed by Calver in 1864, she was found to be one mile N.E.  $\frac{1}{2}$  N. of her charted position; and when fixed by the *Triton* last year, she was found to be one mile and a half S.E. by E. of her supposed position.

The errors probably creep in somewhat in the following way. Something goes wrong with the light-vessel after she has been satisfactorily fixed: a collision takes place, the fog-siren gets out of order, or one of the many things happen which necessitates the vessel being taken into port. A temporary light-vessel is substituted, and she is anchored in almost precisely the same position as the other, but probably before her mushroom bites the ground it has dragged somewhat. By the time the other vessel is repaired and brought out, the temporary one may be a cable or so away from the original position. As the weather is usually thick, the permanent vessel has to be anchored as nearly as practicable in the position of the temporary craft, and her mushroom may drag somewhat before biting the ground, &c. Thus a series of errors creep in without there being adequate means of checking the position of the light-vessel, and within the last few years the *Triton* has found the Leman and Ower light-vessel one mile away from her charted position, the



Dudgeon light-vessel about one mile from her supposed position, and the Outer Downing light-vessel nearly two miles from the charted position.

All these light-vessels are either out of sight of land, or can only be seen from an elevated position on the shore on rare occasions.

It is therefore naturally the object of the Elder Brethren of the Trinity House to utilize the channels closest to the shore, and, as these channels are also the most direct into the Thames, the northern channel following the

general trend of the Essex coast, and the southern that of the Kentish coast, no other channels would require marking if the depth in these was sufficient for the traffic. Hitherto the one northern channel has been enough, but this is steadily shoaling, as will be described further on; but the southern channels are mostly shoal, and one after another has had to be opened up as the size of the vessels and their draught of water increased, until there are now five buoyed channels off the Kentish coast, two of which are lit; but only one can be termed a deep-water channel,



PLAN I.—THAMES ESTUARY. (Depths in Fathoms.)

and this would seem to be the very channel which opens and closes periodically, as will be shown subsequently. Should this prove to be the case, there will be intervals during which there will be no deep-water channel into the river on the south side of the estuary.

By a reference to Plan I., showing, on a small scale, the whole estuary, it will be seen that the northernmost channel, viz. that close to the coast of Essex, is named the Wallet, and that this is separated by a series of banks, termed Buxey and Gunfleet, from the channel next it.

These banks, which are collectively 18 miles long, are dry for the most part at low water; there are, however, two narrow passages across them, one separating the Buxey from the Gunfleet, called the Spitway, and the other separating the Buxey from the Dengie flat (extending from the Essex coast). The Spitway, which, when sounded in 1800, had a depth of nine feet, has remained at that depth until recently, but now has only a depth of 5 feet at low water; the channel between the Buxey sand and Dengie flat has about 12 feet, and is merely an



outlet for the River Crouch. It will therefore be seen that the Wallet is really only a channel to the Rivers Colne, Blackwater, and Crouch, and is of no importance as a channel towards the Thames. It was last surveyed by Staff-Captain Parsons in 1877, and as its features have not materially changed since 1800, it will probably not be surveyed again for many years, unless the swathways across the Gunfleet should deepen or others open up of sufficient importance to render the Wallet useful as a traffic channel. There were formerly other swathways across the Gunfleet, but these are now closed.

The channel next the Wallet is named the King's Channel, or Swin; the eastern part is named East Swin; the central part Middle Swin, and the inner part West Swin. This is the channel through which all the traffic between London and the northern ports of the Kingdom passes, and it is almost always crowded with shipping. The East Swin is bounded at first by the Gunfleet sand to the north-westward and the Sunk sand to the south-eastward, and is 3 miles wide; but 8 miles within its entrance two other banks commence—one, the Barrow, being very extensive, upwards of 13 miles in length and 2 in breadth; and the other, the Middle or Hook sand, a narrow ridge about 6 miles long, extending along the north-west face of the Barrow sand, and leaving a channel nowhere less than  $\frac{2}{3}$  of a mile wide between them. It will thus be seen that 8 miles within the entrance of the East Swin it is split up into 3 channels; the northernmost retaining the same name, the channel between the Middle, or Hook sand, and the Barrow being known as the Middle Deep, whilst the channel between the Barrow and Sunk sands is known as the Barrow Deep. The Middle Deep rejoins the Middle Swin, but the Barrow Deep and West Swin both run into what is known as the Warp. The Swin is well buoyed and lighted throughout, but the Middle and Barrow Deeps have not yet been buoyed. In fact, it has hitherto not been necessary to do so, as the least water in the main channel of the Swin has, up to recently, been ample for all that has been required; but a steady shoaling has been taking place in a critical part of this channel since 1800, and it now seems to be only a question of time before the Middle Deep will have to be marked.

To illustrate the changes in progress here, Plan II. has been constructed, showing the condition of the critical part of the navigation in the Swin each time it has been thoroughly surveyed. By this diagram it will be seen that in 1800 the ruling depth in the channel between Foulness sand and the Middle or Hook sand was 35 feet at low water. Forty-three years later, a bar, on which the depth at low water was 28 feet, had formed between the Foulness sand and the Middle. In 1864 the depth had decreased to 24 feet, and, in 1889, to 21 feet, showing a steady decrease since 1800 of about one foot in every six years. The deposit is of sand, shells, and mud. This is the only shallow part of the Swin; and as it is evident that, so far as our knowledge extends, we may expect it to continue to decrease in depth, and as even now, with strong south-west winds prevailing in the North Sea, it is by no means rare for the tide to fall 3 feet below the level of low water ordinary springs, so that the depth would be reduced to 18 feet, it is clear that vessels of heavy draught will either have to wait for tide or use another channel. Already our small armoured vessels of war have to time themselves to reach this obstruction by half-tide. Fortunately, the Middle Deep is an alternative channel with ample depth in it, which only requires to be buoyed, and this can readily be done. This Deep seems to be in a better condition now than it has been for 50 years, for, when surveyed by Bullock, in 1843, there was a bar of 25 feet at its east end. This had disappeared when it was surveyed by Calver in 1864, and there was then a channel of two cables in width between the edges of the 30 feet contour lines of soundings surrounding the Middle

sand and Barrow. There is now a channel four cables in width between those contour lines in the narrowest part of the Deep.

The Barrow Deep, referred to as the third channel branching away from the East Swin, is deep throughout, and without obstruction. It varies somewhat, as shown by the different surveys, but is an excellent highway, which only requires buoying to be available for traffic. At present the London County Council are allowed to empty rubbish in this Deep, which seems rather a pity, as there is no knowing what may be the result eventually, more especially as we have at present no observations to show to what depth the tidal scour is of service. Any interference with the channels, likely to cause an obstruction, should be avoided.

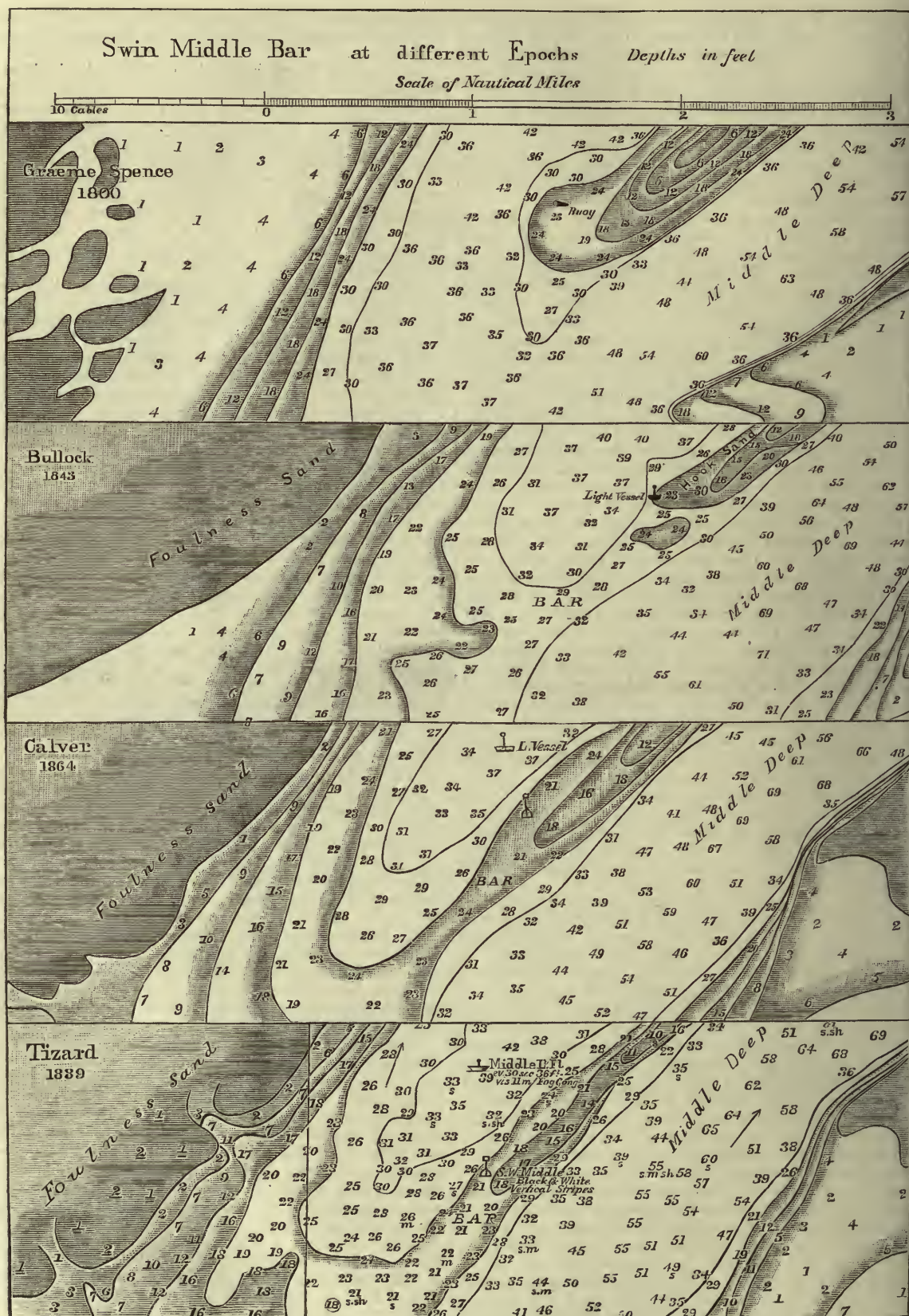
The Sunk sand, which is the south-eastern boundary of the Barrow Deep and the north-western boundary of the Black Deep, has undergone great alterations since originally surveyed in 1800. In that year it is shown as a long sand which really extended from the present north-east end in one continuous line of shallow water to the inner end of the Oaze sand, a distance of 26 miles. On it were many dry patches, named Great Sunk, Little Sunk, Middle Sunk, Knock John, &c., and the only passage across was a three-fathoms channel at low water at the eastern end of the Oaze. When surveyed by Bullock, 1835-45, this chain of sands had altered very considerably, and had several channels or swathways across it—a swathway of 22 feet at low water between the Great and Little Sunk sands; a swathway of 60 feet at low water between the South-West Sunk and the Knock John sands; a 35-foot channel  $1\frac{1}{2}$  mile wide between the Knock John and North Knob sands; and a swathway of 26 feet between the North Knob and the Oaze. When surveyed by Calver, 1862-64, this series of banks had again altered: the swathway between the Great and Little Sunk sands had only 12 feet in it at low water; the swathway between the South-West Sunk and the Knock John had shoaled to 40 feet; but the channel between the Knock John and North Knob had deepened to 45 feet, and a narrow channel of 40 feet at low water had opened out between the Oaze and North Knob.

In 1888-89, when surveyed by the *Triton*, the swathway between the Great and Little Sunk sands had entirely disappeared; the swathway between the South-West Sunk and the Knock John sands had narrowed and shoaled to 29 feet; the channel between the Knock John and North Knob shoals had decreased to 24 feet, whilst the channel between the North Knob and the Oaze had increased its width to one mile, with about the same depth (viz. 40 feet) at low water. In fact, the chain of sands known as the Sunk, Knock John, Knob, and Oaze, which were, in 1800, one continuous bank, after breaking up into separate patches, again show signs of resuming the form they possessed when originally surveyed, the only deep channel across them now being between the Oaze and North Knob.

The Black Deep is the channel bounded to the north-westward by the chain of sands just described, and to the south-eastward by another chain of sands named Long Sand: Shingles, Girdler, and the flats extending from the Kentish shore. It is a deep-water channel, the inner part of which has been buoyed since 1882, and lighted since December last, as it communicates by a deep-water swathway, named the Duke of Edinburgh Channel, with the deep water off the North Foreland, and so forms a convenient outlet for the heavy-draught vessels bound southward from the Thames. There seems to be some tendency to shoal in the north-east end of the Black Deep, but it has only once been sounded—viz. by Bullock, in 1843; and we have not yet quite completed our examination of it throughout, so that no thorough comparison is yet practicable.

The chain of sands which bound the south-east side of





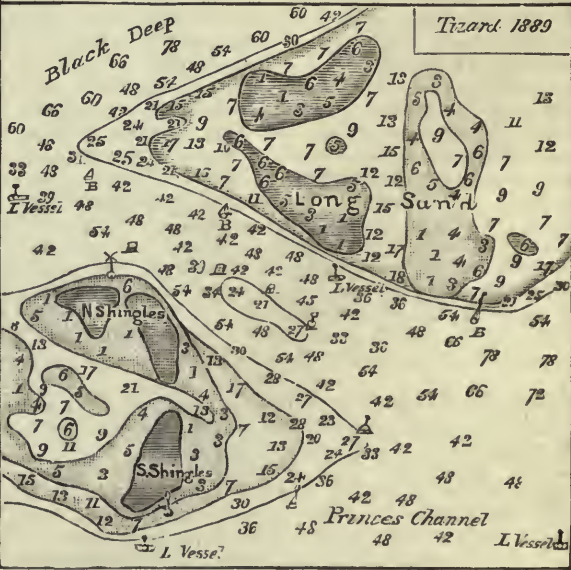
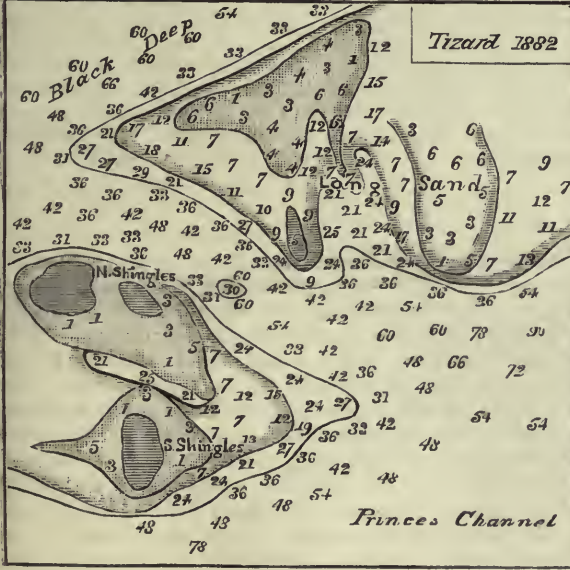
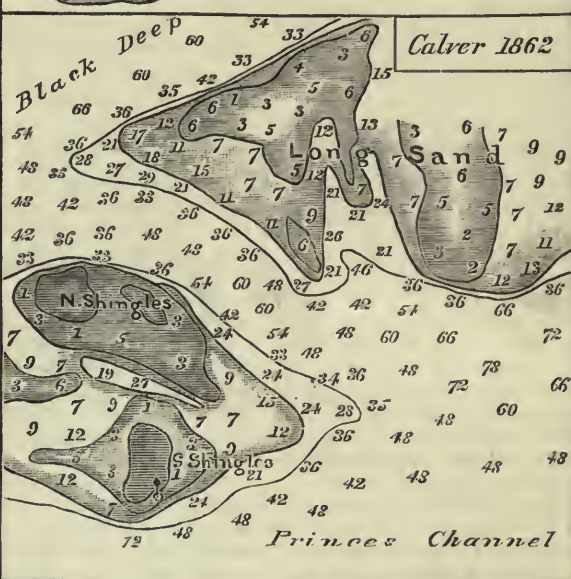
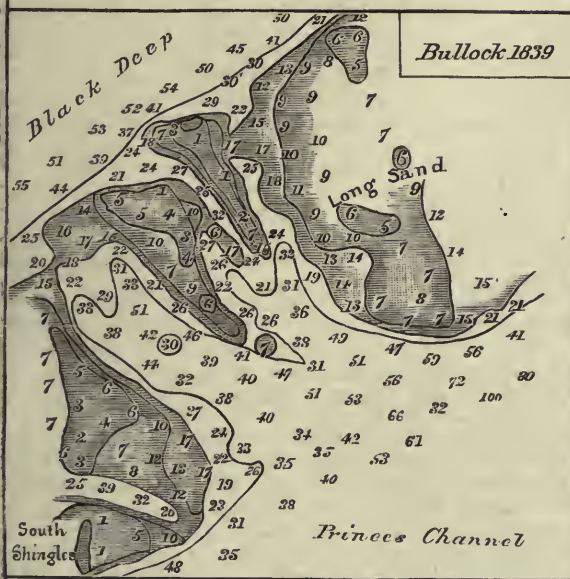
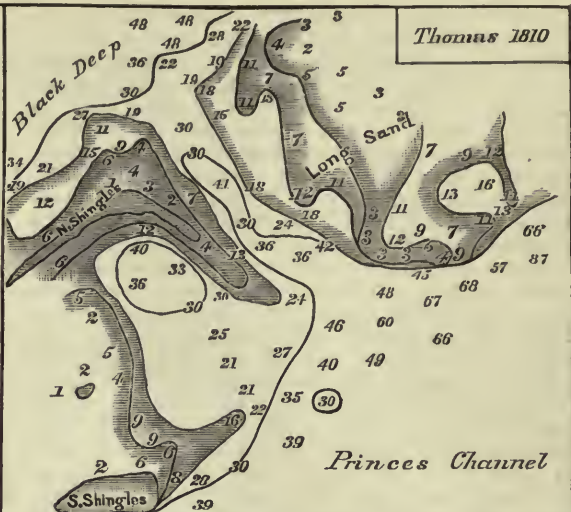
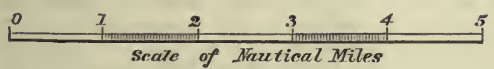
PLAN II.



# DUKE OF EDINBURGH CHANNEL

at different Epochs

Depths in Feet



PLAN III.



the Black Deep formerly extended in one continuous line from the Kentish coast to the Long Sand Head, a distance of over 30 miles. Across this chain of sands there have always been shallow swathways which communicated by somewhat circuitous channels with the deep water of the estuary. These are now 5 in number: (1) the Gore Channel, which passes close to Margate and then across the Kentish flats; (2) the Queen's Channel, which, passing between the Margate sand and Tongue sand, also leads across the Kentish flats; (3) the Prince's Channel, which leads between the Tongue sand on the south side, and the Shingles and Girdler sands on the north side, into the Black Deep; (4) the Alexandra Channel, which leads from the Prince's Channel to the Black Deep; and (5) the Duke of Edinburgh Channel, which leads from the deep water of the North Sea into the Black Deep. All these channels are buoyed. In the Gore Channel (sometimes called the South Channel), which has been in use from early times, the depth at low water is 10 feet. The shallow grounds shift backwards and forwards, but there seems to have been always as little as 10 feet at low water in some parts of this channel. In the Queen's Channel, which was buoyed in the last century, the least depth in passing over the Kentish flats is 13 to 14 feet at low water. In Prince's Channel, which was buoyed in 1846, and lighted in 1848, the least depth is 20 feet at low water, but there is a patch of 17 feet at its western end in the centre of the channel which seems to be always in this channel though not always in the same position. It is shown by Bullock in 1839, by Calver in 1862, and by the *Triton* in 1880. The Alexandra Channel, which is a swathway between the Shingles and Girdler sands, had no existence in 1800, the Girdler and Shingles forming with the Long Sand a continuous chain at that date. In Bullock's survey of 1839, the Alexandra is shown as a blind inlet on the north side of the Prince's Channel, which was cut off from the Black Deep by a ridge over which the depth was 7 feet at low water. When surveyed by Calver in 1862, the least depth in the channel was 20 feet; and when surveyed by the *Triton* in 1888, the least depth was 23 feet. It is, however, much narrower now than in 1862, and if it continues to decrease in width will not be available for traffic, as there is not now much more than room for two large vessels to pass each other, and bad steerage might cause an accident.

Of the Duke of Edinburgh Channel, which is a broad swathway at present dividing the Long Sand from the Shingles Sand, we have a tolerably complete history; and as this would seem to be a channel which opens and closes periodically, Plan III. has been constructed to show its condition each time it has been surveyed. The first record we have of it is on an old chart of 1794, when it is shown as a 9-feet swathway, and is named "Smugglers' swath." When surveyed by Thomas, in 1810, it was named "Thomas's New Channel," and there was then a narrow passage carrying 30 feet at low water between the Long Sand and Shingles. In 1839, when surveyed by Bullock, and named "Bullock Channel," this 30-feet swathway of Thomas's was obstructed by a bank in the middle, which dried at its north end, leaving a passage of 15 feet on its east side, and a very narrow gat of 25 feet on its west side, but one mile farther west a new channel was opening out, the shoalest water in which was 16 feet. This appears as an inlet into the sand-bank on Thomas's chart.

The next time it was surveyed was by Calver, in 1862, at which date Thomas's Channel had closed completely, but the channel west of it had opened out and become a wide deep-water swathway, the least depth in which was 42 feet at low water. Early in 1882 it was thought advisable to buoy this channel, and the *Triton* was ordered to examine it, when a 30-feet patch was discovered near its centre. In the autumn of 1887, this patch was reported to have shoaled; and in 1888, when examined again by the

*Triton*, it was found to be upwards of a mile in length with 22 feet on it. In October 1889, the channel was again examined, when the least depth on the central patch was found to be 21 feet, and it had a tendency to shallow to the eastward. The channel was buoyed in the summer of 1882, and re-named by the Elder Brethren of the Trinity House "Duke of Edinburgh," after the Master of the Trinity House. It was lighted in December 1889.

The various surveys seem to show that the estuary has a tendency for the most part to return to the condition it was in about 1800. In that year there were no deep-water swathways across the banks, and the channels that opened up subsequently seem now to be all closing again. At any rate, those in use as ship-channels evidently will require constant watching.

Should the Duke of Edinburgh Channel close, and none other open out, it will materially interfere with the heavy traffic into the estuary from the southward, for it will necessitate either waiting for high water or passing round outside into the Black or Barrow Deeps, which will have to be buoyed and lighted to make them readily accessible.

There is one other shoal, the "Kentish Knock," which may be said to belong to the estuary. This is a sand-bank about 6 miles in length and 2 in breadth, on the south-east side of the outer part of the Long Sand. Its shape and area, within the contour-line of five fathoms, would appear to be fairly constant; but it had a swathway across the north end, when surveyed by Calver in 1864, which has now entirely disappeared. Between the Kentish Knock and Long Sands is a channel, two miles wide, named the Knock Deep. At the north end of this channel the soundings are much shoaler than when surveyed by Bullock. In some cases the difference is as much as 12 feet.

Although the general tendency of the banks in the estuary seems to be to revert to the condition they were in about the year 1800, it is not possible to predict that this will certainly be the case. If, as seems probable, the condition of the estuary is due to the action of the sea in casting up banks, and of the tidal flow in cutting channels through the banks thus formed, it is evident that much will depend on prevailing types of gales. There can, however, hardly be a doubt that any diminution of the volume of the water running into and out of the estuary would diminish its power of making deep-water channels, so that any action tending to decrease the flow into and out of the various rivers should be avoided if possible; as although it is conceivable that a given type of strong winds, extending over a lengthened period, might have the effect of closing the various swathways across the banks, it does not follow that a cessation of these winds would cause the channels to be again opened out if the volume of the tidal flow was seriously diminished.

T. H. TIZARD.

#### NOTES.

THE respect in which science is held in France was once more exhibited in a very striking way at Saint Sulpice, Paris, on Tuesday, in connection with the funeral service of M. Hébert, Professor of Geology, member of the Institute, and honorary *doyen* of the Faculty of Sciences. Deputations from the Institute and Faculty of Sciences were present, and the Paris correspondent of the *Times* says that all the great scientific and literary institutions of Paris were represented. At the cemetery of Montparnasse, where the interment took place, speeches were delivered by M. Gardry, in the name of the Institute; M. Darboux, in the name of the Faculty of Sciences; M. Marcel Bertrand, in the name of the Geological Society; M. Jannery, in the name of the Normal School; and M. Bergeron, in the name of the old pupils of M. Hébert.